The environment of research.
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This chapter will comment on some of the qualitative aspects of the environment for research as seen by individual investigators, at various career stages, working at universities. The institution's perspectives will also be noted, and also the interaction of these with the incentives and opportunities for unconventional and interdisciplinary initiatives.

1. The investigator's relationship to his/her institution and to the federal grant system.

At the present time, federal funding accounts for ---- % of the support of scientific research at universities. From the perspective of the individual investigator, the dependency on federal funds is even greater, since the non-federal input will be concentrated on faculty salaries and the institutional infrastructure [which is only partly paid for by indirect cost recovery]. For many investigators, no significant funds for the actual conduct of research are available except from federal sources. A momentary interruption of support may not immediately impact the investigator's tenure as a professor, but it poses grave stresses on the continuity of the research, on the employment of technical staff, and on the capacity and opportunity of the investigator to continue a research career.

Since World War II, the scope of federal support for science has constructively expanded that enterprise to the degree that complaints about the details of research adminstration, and their qualitative impact, would have been ungracious. So long as the dependency on federal funds was less than total, private resources could make up for discrepancies that may be difficult to rectify in a government bureaucracy responsive to the politics of both the executive and legislative branches.

In recent years, the overall financial stresses on institutions, coupled with stern policies of federal agencies that limit the institutions' flexibility, and draw down their small uncommitted reserves, have left little buffering capacity on the institutions' part to reinsure against contingencies.

The predictable consequence is a confusion of responsibility for the career interest of the scientist: the federal government has the means but eschews the responsibility, and conversely for the institution. The loyalties of the scientist are likewise divided and confused. Only the most accomplished and fortunate can look beyond the imperative of qualifying for renewal of their research grant. What then suffers are all other activities, including intellectual cooperation in education as well as research, and risk taking in the planning of research.

Further compounding these constraints has been the trend in grants administration, during the past decade, ever more to the project rather than the investigator as the locus of merit. Short terms of grant awards enhance the opportunity and incentive for micro-management of others' research, even on the part of peer scientists. This sets up another vicious cycle, that the burden of grants review constricts the pace and volume of feedback between the investigator and the review process. It is not unusual for an application for a two-year grant to require a year's lead time, and then with very short notice of difficulties that would then imperil the continuity of the work.

There is great value in peer review -- e.g. the gatekeeping of the refereed journals -- which provides indispensable objective criticism and public exposure of new findings and ideas. At present, however, investigators are typically spending 20 - 30% of their time and energy in sustaining the flow of grant support, and in a setting of high anxiety that can only interfere with their creative thinking. (Yes there is some optimal level of accountability and arousal but noone can justify what is experienced today.)

The peer review system is indispensable to maintaining a critical oversight on the quality of science. When this is implemented with such emphasis on projects, and in short term, the stresses on individual careers are matched by the systemic waste that flows from intermittent encouragement and distress, the nurturing of careers that are allowed to sprout, followed by intervals of drought or decapitation. The project system leaves all too little latitude for intra-institutional measures of criticism and support: in a word, careers are being administered, de facto, by a distant bureaucracy that accepts little responsibility for this facet of the scientific enterprise; while the system leaves few resources to local communities of scholars to guide the evolution of their scholarship or the reeducation of their (possibly temporarily) weakest links.

These frictions first frustrate, then deter many young scientists. I am not aware of other than anecdotal evidence that many gifted students are turning away from scientific careers in anticipation of these problems. The evidence is clear that very few M.D.'s now are willing to embrace the risks of a research career as against the incentives of a specialty practice (and against a background of debt for paying for their M.D. education that puts them under extreme burden). While most of the emphasis, perhaps correctly, has been placed on the decline of

secondary and undergraduate education in science, these motivational factors should not be ignored. They are perhaps most clearly telling in the trepidations of well qualified minorities about entering graduate research and careers in science, compared to the safe course of law, business, or medicine.

2. Remedies

A fundamental reconstruction of the federal-university relationship probably exceeds realistic goals, and certainly would require still more extensive deliberation. It appeared to be working admirably from about 1950 - 1965, and while the high rates of annual increase in appropriations cannot be replicated, some other features perhaps can. This approach has the merit of replicating experiments already done.

Some essential features include:

a. Recognition that an institution('s administration) is a processing center for flows of resources, not a primary fount. Whatever the grant system does not provide can only be compensated for by

i) taking resources away from another activity;

ii) discovering other sources (unlikely!)

iii) shrinking the program

Suggestions that "the institution should pay for ..x.." are rarely accompanied by informed mandates as to the sources that should be tapped. :Faculty are often equally ill-informed about this principle, e.g. in discussions of indirect cost recovery:. Complex institutions, like academic medical centers, may need to improve their own cost-accounting for their own awareness of the cross-flows; and many questions doubtless can and should be asked about them. This oversight of institutions's policies is not well done by ad hoc demands around single, vulnerable projects, on the part of agencies that will not share responsibility for the reconstruction that will be entailed.

b. Restoration of emphasis on the creativity of individual investigators, rather than the substance of a research proposal, as the central criterion of merit. Research is after all a foray into the unknown and unpredictable. The skills needed are, above all, those for improvisation in the face of unexpected discovery or disappointment. Those skills are not evenly distributed, and a carefully thought out proposal is important testimony about them. That writing cannot, however, substitute for proven and sustained accomplishment, and especially for research of an exploratory (versus exploitative) character. It is infuriating to see critiques worded like "The investigator has not demonstrated [in advance] that he can [discover such and such]" addressed to individuals who have repeatedly surprised the scientific community (and themselves) with their prior innovations. No wonder that many innovative minds now bootleg their most creative ideas under the cover of "sure-thing" applications; or, as a variant, write their proposals around work already completed. And what a waste that their ingenuity should be so expended!

The NSF and NCI are now "experimenting" with experienced investigator awards ... . details for later discussion.

3. Lengthening the period of award.

The one fell swoop of administrative fiat that could most efficiently achieve the same goals would be a mandate that grant awards again be typically for 5 to 7 years. This would reduce the administrative load of grant review, and on the investigators, especially if there were a period of grace for the more gradual phase-down of a non-renewable project. That interval would also allow for a discourse between applicant and reviewers that is now rigid and full of mutual misunderstanding.

The indirect effects would be equally valuable: it is very difficult even to think of micro-managing projects of such duration. The focus of attention of the applicant would be redirected to basic goals, and of the reviewers to the applicant's personal skills. The time given would allow for opportunistic exploration of unpredictable paths, and for them to face the skepticism of the larger community.

Program managers should also be allowed more flexibility to keep expiring grants "alive" for intervals long enough to allow the threshing out of misunderstanding, or of other occasional but apparent failures of objective peer review. That flexibility is itself an administrative burden; but it will be more tolerable against the background of 7-year than of 2-year awards. Finally, as a university administrator I would frequently have won the bet, if I could make it, of placing funds on a project: that it would be eventually renewed. Some means should be found for the retrospective reimbursement of such gambles when they are in fact legitimated by later reexamination. That is not merely fair: it also enables and encourages insightful management on the part of the university administration.

Industrial contractors have access to risk capital, invested as against expectation of future profit, that is denied to not-for-profit institutions. The measures just suggested are in the spirit of many others that would reward institutional as well as personal skills in the management of creative science. The present system of grant

funding not only makes no provision for that risk capital, it subjects what there is to constant attrition: unilateral flows from cost-sharing, incomplete indirect cost recovery, infrastructural costs, the whole system of faculty compensation which exchanges modest salaries for life-long job security.

c. The entire burden of renovation of the research environment should not and cannot rest solely on federal reform..

Unhappily, most institutions have been socialized to accomodate to the existing system, and with reduced power have abdicated what leadership they might sill exercise in the management of research. This, and what follows, are of course subject to notable but rare exceptions..

The department has become the largest unit that sustains much intellectual and academic cooperation. Students funded from one project can spend some time in another lab in the same department; there is no comparable facility across broader reaches of the university. Above all the project funding system has further bolstered the imperatives of specialization; many able professors have little experience and little culture beyond the domain of their discipline [projects]. In that milieu, there is little occasion for the development of leadership across wider reaches of intellect, even of science. Both structural impediments, and the rarity of the appropriate talent, make it very difficult to install department chairs, deans or provosts who really care or understand very much about the content of the work they are called upon to administer. Nor are faculty likely to be responsive, when their main task is to get their grants renewed. In consequence of these (and many other) factors, many able scientists will properly refuse to involve themselves in formal administrative responsibilities: many chairs, deanships and other executive positions are going begging, or worse are being filled by people with high talents other than academic.

The university, and its professors, have their own responsibilities in attempting to break this vicious cycle of the deprecation of leadership, and its associated ills of the splintering of what historically was a "community" of scholars.

4. Communications in Science

Germane to the health of universities by its bearing on the efficiency of research is the federal government's responsibility for bolstering effective communication in science. ARPANET led the way, years ago. Now it is time for the establishment of effective electronic networking of the entire scientific community. Modest proposals are before the NSF; they are only a decade behind the technological opportunity. I am prepared to discuss this further at a future date. I do not have copies of the appropriate documentation with me at the present time.

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